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ABSTRACT

All contemporary learning theorists agree on the advantages of involving students in authentic problem-solving activities in both in-school and out-of-school contexts. Approaches which use real-world problems as learning tools fit well with: (1) the strategy-based, performance model advanced by information processors; (2) the impasse or perturbation learning model advanced by constructivists; and (3) the socially mediated, apprenticeship model advanced by the cultural anthropologists. Despite its pedagogical popularity, a focus on instrumental problem-solving is subject to criticism because it downplays the role of accommodation in human learning and the transformative role of experience in education. The tendency in this approach is to define the world in negative terms, as a series of obstacles or impediments to overcome. Recent theorists disagree about whether impasse or perturbation facilitates development. There is also considerable disagreement about Vygotsky's perception of the fluid boundary that separates scientific and everyday ways of knowing and its use to support apprenticeship-like, instrumental problem-solving approaches to learning and teaching. An alternative view, idea-based constructivism, focuses more on the possibilities than on the problems inherent in particular situations. Ideas represent perceptual schemata that anticipate the information that might be presented by a particular environment, and hence can "educate attention." Teaching children to be open to perceiving possibilities rather than problems should be a high priority in education. The booklet contains 68 references. (AC)

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Richard S. Prawat

Center for the Learning and Teaching of Elementary Subjects

Institute for Research on Teaching
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Abstract

The advantages of involving students in authentic problem-solving activity is one thing about which all contemporary learning theorists agree. Such an approach fits well with the strategy-based, performance model advanced by information processors, the impasse or perturbation learning model advanced by constructivists, and the socially mediated, apprenticeship model advanced by the cultural anthropologists. Despite its pedagogical popularity, a focus on instrumental problem solving is subject to criticism because it downplays the transformative role of experience in education; the tendency in this approach is to define the world in negative terms, as a series of obstacles or impediments to be overcome. In the alternative view presented in this paper, termed idea-based constructivism, the focus is more on the possibilities than the problems inherent in particular situations.

THE VALUE OF IDEAS II:
PROBLEMS VERSUS POSSIBILITIES IN LEARNING

Richard S. Prawat[1]

In an earlier paper, entitled "The Value of Ideas: The Immersion Approach to the Development of Thinking" (Prawat, 1991), I contrasted three prominent approaches to fostering thinking: The "stand alone" approach, where thinking skills are taught separately from subject matter content; the "embedding" approach, where these skills are explicitly taught in the context of subject matter content; and the "immersion" approach, which differs dramatically from the other two in its emphasis on the role of ideas as opposed to strategies or skills in the development of thinking. I tried to build a case for the third approach, although I recognized it was an uphill battle. The embedding approach enjoys widespread support because it fits with certain information processing biases which continue to exert an important influence in cognitive psychology. Before elaborating on this point, however, it is necessary to introduce a further complication.

As I pointed out in the earlier article, there are two important variants on the embedding approach. Some advocates of this approach prefer a front-end strategy, arguing that thinking skills should be taught prior to their application or use. Others, arguing for the content first approach, believe that thinking skills are best taught on a need-to-know basis (i.e., as students encounter difficulties or obstacles in the handling of particular tasks). The major problem with the skills first approach is that it assumes that knowledge can be acquired separately from the context in which it is used or deployed.

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This assumption has been rightly criticized by constructivists (Brown, Collins, & Duguid, 1989). The danger in this approach is that skills will be developed in an artificial context--one that provides for no real engagement with the world (Goffman, 1974). Advocates of the content first approach, on the other hand, seek to involve students in activities which require the application of certain content-specific thinking skills. It is assumed that students will be highly motivated to acquire a skill if completion of the task depends upon it.

The content first approach is preferable to the skills first approach (Prawat, 1989). Both, however, share a fundamental weakness--one that plagues all approaches based upon information processing theory: While they highlight the role of assimilation (i.e., the fitting of new information into old structures), they do not adequately account for the equally important process of accommodation (i.e., the modification of old structures to fit new information). This, in large part, is attributable to the fact that those who operate within the information-processing paradigm have relied heavily upon the computer as a metaphor. Consistent with this metaphor, many psychologists assume that the most important cognitive processes occur after information is in the system, as it interacts with the human processor's collection of frames or formats. In this scenario, understanding represents a match between the input and whatever abstract structure best fits this input (Schank, 1975).

As I argued in my earlier paper, adoption of the computer metaphor has contributed to our current preoccupation with thinking strategies--or "thinking frames" to use Perkins's (1987) expression. Because I was primarily interested in offering an alternative (i.e., the immersion approach) to this set of strategy-based approaches in that paper, I chose not to elaborate on what I see as an important additional connection between the content first

approach and two other prominent perspectives in the field: constructivism and what might be termed the cultural/anthropological approach to learning and teaching. Each of these perspectives (i.e., information processing, constructivism, and the cultural/anthropological) plays off the other. The consensus that has emerged from these three theoretical approaches can be summarized as follows: The ideal learning situation is strategic, it is problematic, and it is situated or authentic. This last criterion grows out of the cultural/anthropological tradition, which considers apprenticeship learning to be the best example of an experience that meets all three requirements.

Prevailing theory, then, points to authentic, strategic, and problematic situations as the ideal tools for learning in both in-school and out-of-school contexts. The remainder of this paper is devoted to a critical examination of this proposition.

Instrumental Problem Solving and Current Theories of Learning and Cognition

As I suggested earlier, the advantages of involving students in authentic problem-solving activity is one thing about which all contemporary learning theorists appear to agree. Such an approach fits well with the skills-oriented, performance model favored by information processors, the impasse or paradoxical learning model favored by constructivists, and the socially mediated, apprenticeship model favored by cultural anthropologists. This represents an impressive amount of support. Nevertheless, there are problems associated with this particular view of the ideal learning situation. Viewing the world as a series of problems to be overcome, although more engaging than traditional views that emphasize the mastery of decontextualized facts and procedures, is still too restrictive. What is slighted in the instrumental problem-solving approach is the <u>trans</u>formative as opposed to <u>in</u>formative aspects of one's interaction with the world (Prawat, 1991). An instrumental

orientation to learning on the part of teachers may not adequately stimulate students' imagination. Education should open students to new opportunities; as Egan (1990) argues, it should encourage students "persistently to wonder about the world, and to satisfy their wonder with a further wonder" (p. 218).

Before offering an alternative vision of learning, one which places at least as much emphasis on the imaginative aspects of the process, it would be wise to examine arguments for and against a problem-solving approach.

The Case For and Against Instrumental Problem Solving

Authentic problems are thought to represent a unique kind of situation, one in which individuals know what it is they want to accomplish but haven't developed the means for getting there yet (Newell & Simon, 1972). The tension that arises from this means-ends discrepancy supposedly serves as a powerful incentive, forcing individuals to access and utilize intellectual resources that otherwise might remain inert. In the school context, problem solving is thought to result in the "proceduralization" of factual or declarative knowledge, resulting in more meaningful learning which prepares students to function effectively in the real world (Bransford & Vye, 1989). For these reasons, problem solving appears to represent the ideal learning situation. It is also fairly uncommon in the typical classroom, according to some theorists.

Brown et al. (1989) contrast what often passes for problem solving in the classroom context with what one finds in authentic, real-world settings. Math word problems, for example, as an archetypal school activity, bear little resemblance to math practice outside of school. There is nothing problematic about word problem exercises, which can often be solved by direct application of the procedure illustrated in the textbook passage preceding the exercise (Schoenfeld, 1989). The means in word problems are thus well defined;

furthermore, there is often little real-world or instrumental value associated with attaining the ends--unlike authentic math practice. This last factor is particularly important; the desired outcome in instrumental problem solving must matter in some material way (Putnam, Lampert, & Peterson, 1990). It should meet some practical end, like ensuring that prize money is equitably distributed. Subject matter knowledge is valuable if it is relevant to solving everyday problems where a correct solution matters.

As Floden, Buchmann, and Schwille (1987) point out, the tendency to equate the value of learning with its practical application goes way back in American education. Dewey is often cited as a key proponent of this philosophy; it was Dewey, after all, who labelled as "worse than useless" subject matter instruction which did not connect with problems "already stirring in the child's experience" (Dewey, 1910, p. 199). However, as Floden et al. (1987) point out, Dewey was profoundly ambivalent about the "relevance" issue: "Dewey saw education as a journey into the unknown. Experiences are not 'educative' if they only give students 'greater skill and ease' in dealing with things with which they are already familiar" (p. 500). Dewey also believed that education should open youngsters to the unique kind of experience that results from the mastery of subject matter knowledge--knowledge which otherwise would be inaccessible to the young if left "to pick up their training in informal association with others" (in Floden et al., 1987).

In an instrumental or functionalist approach to learning, problems are viewed as "pathologies." They represent obstacles to goal attainment and thus limit or constrain our freedom (Skrtic, 1991). The focus in instrumental problem solving, to use Greene's (1986) expression, is on negative as opposed to positive freedom (i.e., freedom <u>from</u> constraints or obstacles). To the extent to which this focus generalizes, the world is seen as a series of

impediments or obstacles to be overcome in attaining one's personal or social goals; in such a case, students likely will assign the highest value to procedural knowledge (Floden et al., 1987). There is an alternative to this instrumental preoccupation, according to Greene (1986)--one which focuses less on the problems and more on the possibilities inherent in a particular situation. This second orientation represents freedom in the active or positive sense: "The freedom linked to an awareness of the unpredictable, the possible" (p. 74).

Imagination plays a key role in opening one up to the power of possibilities, Greene believes, seconding Egan (1990) in this regard. A "skills orientation," Greene (1986) writes, is attentive insufficiently to the "power of possibilities" (p. 74). Greene offers the following as an example of the type of learning experience she envisions as constituting an alternative to "technical rationality":

> I cannot but think of how the Carvaggio paintings I saw a while ago disclosed themselves to me because I had come to know a little about moving into pictorial frames, experiencing the space moving outward, noticing color relationships: the dark coming, that startling, tragic light on faces, arms, hands that could have been my own. And, as in the case of painters like Turner, Cezanne, van Gogh, Hopper, I realized that there would be more to see each time I returned. (p. 77)

At the end of this passage, Greene raised a key question, one which advocates of the prevailing paradigm in cognitive psychology would do well to ponder: "How would the model of technical rationality account for what is involved in teaching someone, enabling someone to have experiences like those?" (p. 77).

Skills-oriented, instrumental problem-solving approaches to cognition are not well equipped to deal with the sort of issue raised by Greene. Contemporary theories of learning have yet to develop an adequate account of how the transformative or accommodatory process works (Prawat, 1991). As Bereiter (1985)

explains, "It seems to be generally agreed that there is no adequate theory to explain how new organizations of concepts and how new and more complex procedures are acquired" (p. 201). Neisser (1976) commented on this problem nearly 15 years ago. He attributed it to the shortcomings of information processing theory, with its heavy reliance on the computer as a model of cognition. The problem with this model, according to Neisser, is that it assumes that the most important part of the process occurs after information gets into the system. Thinking is synonymous with the manipulation of information, its classification, organization, and retrieval. Little attention is devoted to how the processor experiences and adapts to his or her environment. In fact, as Cobb, Yackel, and Wood (1988) point out, it is a contradiction to embrace the computer metaphor while acknowledging the role of experience: "Computers do things, they perform, but they do not experience. There is a contradiction in our activity if we talk about the importance of experience and develop performance models--we cannot have it both ways" (p. 32).

In a sense, psychologists and educators are trying to have it both ways. That is one of the main arguments of this paper: They have continued to cling to performance models, albeit in the form of thinking "frames" or "formats," while attempting to incorporate insights from more recent constructivist and cultural/anthropological research on learning and cognition. The result is an interesting mix of the new and the old. It is fair to attribute the current focus on thinking strategies to the continuing, strong influence of information processing theory (Prawat, 1991). Similarly, a growing appreciation for the role of perturbation during learning can be linked to constructivism (Steffe, 1990; Yackel, Cobb, & Wood, 1987). Finally, cultural/anthropological perspectives (i.e., Vygotskyian theory) have profoundly influenced current thinking about context and the role of social mediation in learning and

cognition. The confluence of these various theories and approaches, I submit, accounts for what is currently regarded as the ideal learning situation--best described as authentic, socially mediated, instrumental problem solving.

Instrumental Problem Solving, Learning Theory, and School Subjects

Before presenting evidence on the role of problem solving in the various subject matter domains, it might be helpful to illustrate how this issue plays out in each of the three contending theoretical camps: information processing, constructivist, and cultural/anthropological.

Problem solving and learning theory. The goal in information processing theory is to construct a richly elaborated process model of student understanding. Only when processes are described in "complete, painstaking detail" are they open to "trial by simulation" (Simon, 1981, p. 156). Trial by simulation represents the ultimate test according to information processors: "If a theory is not sufficiently well-formed to run on a computer it probably won't run on a brain either" (Miller, 1989). Because of the focus on process in information processing theory (i.e., knowing how), strategic detail receives more than its fair share of attention (Prawat, 1991). It also drives us toward a certain type of performance--namely instrumental goal-directed action (i.e., problem solving). Strategic knowledge is goal dependent (Ohlsson & Rees, 1991). It can be judged more or less effective: As Ohlsson and Rees put it, "Executing a certain action in a particular situation will lead to attainment of the relevant goal with more or less expenditure of time, cost, or effort" (p. 110). This instrumental test is unique to strategic knowledge. Declarative knowledge (i.e., knowing that), in contrast, is evaluated according to much more subjective criteria: It must be personally meaningful; that is, it must fit with, and extend, what one already knows (Von

Glasersfeld, 1987). It must also be consistent with the institutionalized knowledge shared by those in relevant disciplinary communities (Cobb, 1988).

Information processing theorists thus tend to design their theories with instrumental problem solving in mind. Schoenfeld (1987) is a case in point. His initial work on mathematical problem solving was heavily influenced by information processing theory. He was inspired, he writes, by classic work in artificial intelligence. His ultimate goal was to come up with a useful set of heuristics that students could use in their own mathematical problem solving. He realized that one "couldn't 'program' students like computers," but he thought he could describe the process "with enough precision and in enough detail that students could take those characterizations as guidelines for problem solving" (p. 18). Thus, Schoenfeld found the computer metaphor upon which information processing is based to be a compelling one in his early thinking. It provided both a general framework for thinking about mathematical problem solving--as strategies "working" on knowledge--and the incentive to dig deeply enough into specific situations to understand how the process unfolds.

Constructivists have a different rationale for focusing on instrumental problem solving as the paradigmatic learning situation. As indicated above, the importance assigned to the role of perturbation in the learning process appears to be the key factor in this regard. Thus, Steffe (1990), one of the key proponents of constructivism in mathematics, describes his view of learning as follows:

> Essentially, mathematical learning involves accommodation of current mathematical concepts to neutralize perturbations that can arise in one of several ways. As such, it includes what Polya (1962) meant when he stated that to have a problem means "to search consciously for some action appropriate to attain a clearly conceived, but not immediately attainable aim." (p. 393)

Yackel et al. (1987) second this notion. One clear implication of constructivism, they write, is it that it should be problem centered. Duckworth (1987), who bases her constructivism on Piagetian theory, agrees with this idea. "Practical situations," she writes, are the best kind of learning situations: "In the course of trying to solve practical problems, children spend time reorganizing their levels of understanding" (p. 49). Scholars who regard themselves as constructivists in other disciplines, such as science and social studies, make the same point (Herron, 1990; Parker, 1989).

Researchers operating from a cultural/anthropological perspective consider problem solving to be the ideal type of learning situation. In most cultures around the world, including our own, people readily acquire valuable knowledge and skill by participating in the everyday practices of the culture: "Given the chance to observe and practice in situ the behavior of members of a culture, people pick up relevant jargon, imitate behavior, and gradually start to act in accordance with its norms" (Brown et al., 1989). Often these practices involve an informal type of shared problem solving. Saxe's (1990) ethnographic work with candy sellers in Brazil illustrates the power of this sort of arrangement.

Saxe (1990) found that candy sellers, although often unschooled, evidenced impressive levels of mathematical understanding. Surprisingly, they were more adept than children of the same age at the second-grade level in their use of one sophisticated solution strategy in arithmetic: Regrouping numbers into more manageable units (i.e, 26 + 28 being treated as 20 + 6 and 20 + 8). Saxe attributes this advantage to the goal-directed nature of the out-of-school vending experience: "Candy-selling practice," he writes, "is a social context in which problems are configured as a result of the structure of the practice itself, a structure that is supported by a variety of social

processes" (p. 222). Included in the latter category is assistance from wholesale clerks and from other, more experienced peers.

More formal apprenticeship arrangements, where novices are coached systematically and guided by expert practitioners, are even more powerful learning experiences. In fact, the apprenticeship system is often put forth as the most effective way to foster learning: Novices learn by doing in a culturally valued problem-solving context. Their participation is carefully monitored by experts who work alongside them, providing just the right amount of support or scaffolding for the novice so that there is a gradual shift in responsibility for the activity. "Apprentices," Lave (1988) writes, "learn to think, argue, act, and interact in increasingly knowledgeable ways with people who do something well, by doing it with them as legitimate, peripheral participants" (p. 2). Anthropologists have studied a range of out-of-school learning situations of this type, including tailoring (Lave, 1977), weaving (Greenfield & Childs, 1977), and pottery-making (Price-Williams, Gordon, & Ramirez, 1967).

Impressed with the effectiveness of the apprenticeship approach, researchers in diverse school subjects such as mathematics, reading, and writing have developed versions for use in the classroom. The examples described by Collins, Brown, and Newman (1989) are said to approximate closely the real-life teaching of expert craftsman. The idea is to teach problem-solving strategies in a holistic way, where both the purpose and the effect of the activity is relatively transparent. Teachers model carefully expert strategies for students (e.g., paraphrasing main ideas in reading or hypothesizing about the future content of passage segments), providing hints or suggestions along the way; this support is removed gradually as students demonstrate that they can function on their own.

The cultural/anthropological work cited above has been strongly influenced by the theorizing of Vygotsky. Vygotsky (1978) emphasized the importance of social relations in the development of all forms of complex mental activity. Internalization is the process whereby certain aspects of activity performed on an external plane come to be executed on an internal plane: "Any function in the child's cultural development appears twice, or on two planes. First it appears on the social plane, and then on the psychological plane" (p. 57). Internalization involves a transfer of responsibility from expert to novice, teacher to pupil; the arena for this transfer is the zone of proximal development, defined as the distance between the child's current level of independent problem solving and what he or she is able to do under adult guidance.

Less clear in Vygotskyian theory is exactly what it is that is being transferred. Americans have tended to focus on thinking skills or strategies (Belmont, 1989). Rogoff (1990), for example, a prominent Vygotskyian, stresses the instrumental and strategic nature of thought: Thinking is problem solving, she writes, and its purpose "is to act effectively" (p. 14). Children internalize problem-solving strategies by participating with adults and more expert peers in authentic problem-solving activities. In this context--and when provided with expert models--they learn to "mentalize" external, practical action in the classroom. As I will argue shortly, there is an alternative interpretation of Vygotskyian theory--at least as it relates to his views about the zone of proximal development--one which emphasizes concepts or ideas much more than strategies (Kozulin, 1986; 1990). Nevertheless, it should be obvious by now that researchers operating from all three theoretical perspectives (i.e., information processing, constructivism, and cultural/anthropological) strongly endorse a strategy-oriented, instrumental

problem-solving approach to teaching and learning. Not surprisingly, this bias figures prominently in current recommendations for improving subject matter instruction at the K-12 level.

Problem solving and the acquisition of subject matter. Mathematics is one of the most obvious sites for an instrumental problem-solving approach to teaching and learning. For at least 15 years, mathematics educators have been calling for a greater emphasis on problem solving. In a position paper issued in the late 1970s, the National Council of Supervisors of Mathematics (1977) expressed its view that "learning to solve problems is the principal reason for studying mathematics." In 1980, the National Council of Teachers of Mathematics listed as its number-one recommendation for improving instruction that "problem solving be the focus of school mathematics" (p. 2). This statement was later repeated in the influential recent standards document put out by that organization (NCTM, 1989). Romberg (1988), who played an important role in developing the standards, presents an example of problem-focused instruction: Fifth-grade students view a videotape of the 100-meter dash at the Olympics. Their task is to count the number of steps, estimate the length of the steps, average the time per step for the winner, and compare this with similar data on the second- and third-place finishers. This example is consistent with Scribner and Cole's (1973) admonition to strip education from the schoolroom and make it instrumental in everyday life, advice that is being heeded in other disciplines as well.

According to Michaels and O'Connor (1990), the information-processing conception of literacy has re-oriented the field, away from a focus on mechanistic decoding and encoding skills toward a view that credits the reader with a far more complex repertoire of cognitive strategies. Literacy, according to this current view, involves a kind of "problem solving with print" (p. 5).

The focus is on how people learn from text. More is involved than simply taking in and repeating information. Good readers make flexible use of a number of strategies to "foster, monitor, regulate, and maintain comprehension" (Dole, Duffy, Roehler, & Pearson, 1991, p. 242). Presumably, it is this last aspect of reading--the utilization of variable means to achieve a clear purpose--that makes reading analogous to other forms of instrumental problem solving. (The clear purpose in this approach to reading, incidentally, has been described as the ability to answer questions on text.) Skilled writing is also considered a problem-solving activity; here, certain rhetorical problems are more or less correctly solved for different audiences and purposes (Michaels & O'Connor, 1990; Flower & Hayes, 1980). It is worth noting that the tendency to view teaching and learning in other subjects, like science and social studies, through a problem-solving lens is also on the increase (Voss, 1987).

The widespread endorsement of an instrumental, problem-solving schema across various learning theory and curricular domains is beyond dispute. In information processing theory, a continuing commitment to the role of frames or formats in structuring thought has diverted attention away from nonstrategic, perceptually based alternatives (Neisser, 1976; Prawat, 1991). Constructivist theory lends indirect support to strategic problem solving by its emphasis on the role of impasse or perturbation in learning: As VanLehn (1988) puts it, "Learning occurs only when an impasse occurs. If there is no impasse, there is no learning" (pp. 31-32). Finally, Vygotskyian theory, as least as currently understood, adds yet another piece to the puzzle by arguing that practical activity forms the basis for all higher level mental activity. Each of these arguments deserves closer attention.

Assumptions Supporting an Instrumental Problem-Solving Approach to Teaching and Learning

The three major premises upon which instrumental problem solving is based have been subjected to scrutiny recently. First, the focus on process or strategy, which Neisser (1976) attributes to the popularity of the computer metaphor, has been criticized on the grounds that it downplays the role of accommodation in human learning. According to this argument, strategy or frame-based approaches place too much emphasis on the utilization of past experience; that is, on the assimilation of new information into existing frames or formats. Information processing theory places too little attention on the sort of accommodatory experience described by Greene (1991)--the purpose of which is to foster "involved and informed" encounters with the world: "To be fully present depends on understanding what is there to be noticed in the work at hand, releasing imagination to create orders in the field of what is perceived" (p. 29). Although Greene is talking primarily about art education, she sounds a lot like Neisser (1976), who insists that individuals as well as schemas undergo accommodation during perception: The perceiver "creates and changes himself by what he perceives and does in the present" (p. 53). As I will argue shortly, imagination is the accommodatory mechanism that opens individuals to new experience--and ideas, not strategies, serve to channel or direct this process.

A second assumption underlying the instrumental problem-solving approach also bears further examination. This is the notion that perturbation or disruption is growth producing. Problems, by definition, are perturbations; they represent obstacles to goal attainment. Constructivists value the motivational effects that result from such encounters. However, current research questions the role of impasse during learning.

Finally, a reinterpretation of Vygotsky's theory raises serious doubts about the importance he assigned to "practical activity" in his own thinking. According to Kozulin (1986), Vygotsky's treatment of this issue was distorted by his disciples--largely for political reasons. The role of symbolic mediation in intellectual development was downplayed in favor of a much more direct relationship between consciousness and reality: "The thesis of 'actual relations with reality' fitted the Soviet dialectical-materialistic credo circa the 1930s much better than the more complex cultural-historical model suggested by Vygotsky" (p. 270). The concept of practical activity thus underwent a metamorphosis following Vygotsky's death. As Kozulin points out,

> The most dramatic event in the history of the concept of activity occurred in the mid-1930s when a group of Vygotsky's disciples came up with a "revisionist" version of activity theory that put practical (material) actions at the forefront while simultaneously playing down the role of signs as mediators of human activity. (p. 264)

Vygotsky emphasized the importance of socially constructed "psychological tools," particularly concepts, in all forms of complex human mental functioning.[2]

Researchers in the cultural/anthropological tradition have been influenced strongly by Vygotskyian theory--particularly his purported belief in the common origins of external, practical activity and internal, mental activity. Because Kozulin's (1986) reinterpretation of Vygotskyian theory raises doubts about this aspect of his theory, it also raises doubts about the appropriateness of apprenticeship learning as a model for complex human cognition.

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[2]It is interesting in this regard to note that in the most widely quoted statement by Vygotsky--which Wertsch (1985) terms the "general genetic law of cultural development" (p. 60) (see above, p. 14)--one sentence is invariably omitted. Specifically, Vygotsky talked about how functions in the child's cultural development appear twice--first between people then within the child. Then he added, "This applies equally to voluntary attention, to logical memory, and to the formation of concepts" (emphasis added) (Vygotsky, 1978, p. 57).

I will begin with a discussion of information-processing theory and its well documented problems in accounting for the process of accommodation (Berieter, 1985; Fodor, 1980).

Assimilation versus accommodation. Strategy-oriented approaches, in general, and instrumental problem-solving approaches in particular, are not well equipped to deal with the transformation of schemes or structures (Prawat, 1991). They emphasize assimilation, or the fitting of new information into pre-existing cognitive frames or formats, and slight or ignore the important process of accommodation. Block (1983) defines this second process as the "modification and formation of cognitive schemes capable of encompassing new information or experience" (p. 1346). She further argues that, while both modes serve an adaptive function, individuals may come to rely too much on one or the other. According to Block, school can influence the extent to which the focus is on "conserving existing structure" (assimilation) or creating "new adaptive modes" (accommodation) (p. 1346). In current calls for reform, I submit, the assimilatory function is likely to predominate. This should be a cause of some concern.

Egan (1990) presents some of the strongest arguments in favor of righting the balance between assimilation and accommodation in the classroom. There is too much emphasis, he argues, on reason (i.e., "technics of thinking") and not enough on imagination, which he defines as "the making, composing, vivifying power" (p. 166). Thus, in Egan's scheme, imagination plays an accommodatory role (as it does in Greene's (1991), see above). Egan attributes the tendency to slight this aspect of thought in favor of logical thinking to the sort of "technocratic" thinking that prevails in psychology and other domains:

> "Composing," "poetry," and "making" all highlight a constituent of learning that has tended to be rather suppressed as a result of psychology's influence, and the difficulty the dominant methods of psychological research have had in getting much hold on this constituent of learning. These alternative metaphors point to an

element of learning which became prominently recognized, in somewhat different ways, in the Enlightenment and in the Romantic movement (i.e., the imagination). (p. 132)

Before elaborating further on Egan's (1990) views, I must make a case for the assimilatory nature of most strategy-oriented approaches to learning--a subset of which, of course, involve instrumental problem solving. As indicated earlier, strategies represent frames or formats. They provide the mental organization or structure necessary if one is to act effectively in a particular situation. One set of frames plays an executive role, guiding or controlling actions in particular situations. Planning is an example of a general frame that plays this role. It serves as a reminder--perhaps in the form of self talk--to think carefully about an activity before initiating a response. Planning may involve slightly different processes in different subject matter domains. In reading, for example, it might consist of skimming the entire text to get a feel for its overall structure, deciding how best to allocate one's time in order to maximize learning, and so forth. In mathematics, activation of a variant on this general frame could result in what on the surface appears to be different behavior: Outlining a solution to a problem at a very general level, for example, prior to elaborating it in detail as the solution proceeds. Other executive control processes, like monitoring, checking, and revising, are also thought to be similar across different domains of application (Prawat, 1989).

A second set of thinking frames are more reactive in nature. Often referred to as critical thinking skills, they channel thought in an indirect way by allowing one to evaluate the adequacy of various intellectual products, including one's own. Looking for bias in information sources represents an

example of a critical thinking process organized or supported by this second type of frame.

As Winograd and Flores (1987) point out, frame-based computational systems have been used by artificial intelligence researchers for some time. The adoption of this sort of system represents a deliberate decision on the part of cognitive scientists to focus exclusively on the assimilatory aspect of cognition: Programs based on frames, scripts, prototypes, perspectives, write Winograd and Flores, "all deal with ho' a previously existing structure guides the interpretation of new inputs. The emphasis is on recognition" (p. 115). They elaborate further a little later in the text, writing that frame-based systems

> concentrate not on the question "How does the program come to accurately reflect the situation?" but rather "How does the system's preknowledge (collection of frames) affect its interpretation of the situation?" The meaning of a sentence or scene lies in the interaction between its structure and the pre-existing structures in the machine. (p. 116)

Initially, write Winograd and Flores (1987), artificial intelligence researchers opted for a more balanced approach, one that tried to model the process of representation (i.e., accommodation) along with that of information manipulation. It was at this point that the limitations of machine intelligence became most evident: Computers, unlike humans, are stuck with the representations provided for them, creating a peculiar sort of blindness to new ways of representing the world which constitutes a fatal flaw in all but most circumscribed domains: "The program is forever limited to working within the world determined by the programmer's explicit articulation of possible objects, properties, and relations among them. It therefore embodies the blindness that goes with this articulation" (p. 97). Humans, in contrast, create representations but are not limited to them:

> When we accept (knowingly or unknowingly) the limitations imposed by a particular characterization of the world in terms of objects

> and properties, we do so only provisionally. There always remains the possibility of rejecting, restructuring, and transcending that particular blindness. This possibility is not under our control--the breakdown of a representation and jump to a new one happens independently of our will, as part of our coupling to the world we inhabit. (p. 99)

It was the computer's inability to transform structure in this way that led to the adoption of frame-based approaches to information processing. The adoption of these approaches, in turn, has done much to legitimate the current focus on assimilation.

Egan (1990) suggests a novel antidote to this situation, which involves reaching back in time to heed advice first offered by nineteenth-century Romantics like Blake and Wordsworth. Egan's argument is germaine to this paper if one assumes that his use of the terms reason and imagination resemble my use of the terms assimilation and accommodation. This is not a far-fetched notion. In fact, Rorty (1989) supports this contention in his brief characterization of the Romantic movement: "What the Romantics expressed as the claim that imagination, rather than reason, is the central human faculty was the realization that a talent for speaking differently, rather than arguing well, is the chief instrument of cultural change" (p. 7).

It was the Romantics, Rorty adds, who first understood the importance of perspective--the notion that "anything could be made to look good or bad, important or unimportant, by being redescribed" (p. 7). If seeing things in a different light is the essence of imagination, then the process does resemble that of accommodation. Furthermore, if arguing well lies at the heart of the reasoning process, and if this process, in turn, involves bringing to bear certain logical frames or formats (cf., Prawat, 1991), then one can draw parallels between the reasoning process and assimilation as it is defined in this paper.

Imagination as accommodation. As Rorty's (1989) quote suggests, the Romantics felt that Enlightenment scholars had placed too great a reliance on reason to the detriment of imagination. William Blake, the nineteenth-century poet, was one of the most explicit in this regard:

> The Spectre is the Reasoning Power in Man, & when separated
> From Imagination and closing itself as in steel in a Ratio
> Of the Things of Memory, it thence frames Laws and Moralities
> To destroy Imagination, the Divine Body, by Martydoms & Wars.
> (quoted in Egan (1990), p. 82).

Most Romantics, however, sought to temper rather than negate the role of reason. They believed that the cultivation of imagination led to a sense of wonder and awe about the world. Egan (1990) elaborates on this idea. According to Egan, instruction must do more than simply engage students' interest: "The focus rather is on engagement with the wonders of the world and human experience and, as a consequence, the extensive amassing of considerable and diverse knowledge about them" (p. 229). The way to do this, Egan argues, is to involve them in the world of ideas--ideas that can help bring to life important aspects of the students' world. In an argument similar to the one presented in this paper, Egan believes that ideas must be situated or contextualized if they are to be understood: The purpose is "not to give definitions of ideas but to help students flexibly to grasp their complexity by multiple examples" (p. 225).

As I will argue shortly, righting the balance between assimilation and accommodation in American education may require more than a change in curricular focus (i.e., less emphasis on strategies and instrumental problem solving, more emphasis on ideas). It may require adoption of a new metaphor in cognitive psychology, one based on perception instead of the prevailing frame-based computer metaphor. As Winograd and Flores (1987) suggest, the limitations of the computer metaphor are becoming more and more apparent to

those operating within the information-processing tradition. Before making a case for an alternative approach, however, I want to return briefly to two issues raised in the introduction to this section: The first concerns the role of impasse or perturbation in learning. The second concerns Vygotsky's views about the role of practical activity in intellectual development. Recent work by scholars like Kozulin (1986; 1990) indicates that Vygotsky actually assigned much less importance to the role of practical activity in his theory than is commonly thought; instead, he emphasized the importance of concepts or ideas as the most important intellectual resource in the development of higher level thinking.

Constructivists have assigned a prominent role to impasse in learning; those operating within the cultural/anthropological tradition have done the same thing for practical activity. The fact that these variables play such an important role in the learning process constitutes a further argument in favor of the instrumental problem-solving approach in education. Conversely, any doubts I can raise about the role of either in the ideal teaching/learning situation could be considered as an argument against adoption of this approach.

The role of impasse in learning. As indicated earlier, constructivists, at least in mathematics, believe that instruction must be problem-centered (Yackel et al., 1987). There appears to be an impressive amount of support for this hypothesis. Piaget's theory assigned a key role to disequilibrium, the uncomfortable feeling associated with states of cognitive conflict or discrepancy. The need to deal with such a situation apparently serves as a powerful motivator to modify or change existing knowledge and action. Problems thus have the potential for producing intellectual growth.

Research in other genres has contributed to the view that impasse or perturbation facilitates development. Brown and VanLehn's (1980) work on mathematical "bugs" is a good example. Bugs represent rule-like distortions of normal procedures in mathematics; examples include borrowing across zero during subtraction, or always subtracting the smaller number from the larger in a column, even when it is on the bottom. VanLehn (1986) argues that children invent these procedures when they encounter an impasse in carrying out a procedure. Children, feeling the press to continue in their efforts to solve the problem, but unsure how to proceed, induce a workable solution by generalizing from previous examples. Again, it is the impasse that leads to the creative, if sometimes incorrect, solution.

Recent work by Siegler and Jenkins (1989) questions the intuitively reasonable notion that necessity is the mother of invention. Siegler and Jenkins used an exceedingly fine-grained approach to examine the development of a common counting strategy in children--the so-called "min" strategy, which involves counting on from a larger number. The preschoolers participating in their study were assessed continuously over an 11-week period. After being given repeated practice on single digit addition problems, these children were presented with certain challenge problems (e.g., 2 + 21) toward the end of the assessment period. Siegler and Jenkins (1989) explicitly tested the hypothesis that impasse leads to discovery. Their data, however, led to a rejection of that hypothesis. As Siegler and Crowley (1991) point out, most often the min strategy was discovered when children were working on easy problems which had been solved correctly at an earlier point in the experiment. Furthermore, there was no evidence of children being stymied by difficult problems immediately preceding the discovery. Trial-by-trial data did suggest that a transition strategy was used by those who eventually discovered the min

strategy; this strategy was a hybrid of the counting all and the counting on or min strategy.

Based upon the results of this study, Siegler and Crowley (1991) question the common assumption that psychological change is in reaction to perturbation or conflict. This, they assert, "relegates change to a conditional status" (p. 614). The alternative, which they suggest is supported by a growing body of research (Karmiloff-Smith, 1984; Bowerman, 1987), is to regard change--or accommodation--as the norm rather than the exception, "as continual, rather than sporadic or periodic" (p. 614).

Vygotsky and the role of practical activity. Zinchenko (1984), a member of the Kharkov group that purged Vygotskyian theory of its bourgeois elements, felt that Vygotsky placed far too much emphasis on the role of concepts and other psychological tools in the development of the human mind. He felt that Vygotsky had incorrectly given an idealistic spin to Marxist theory. This, Zinchenko said, was Vygotsky's "fundamental error" (p. 270). To right this wrong, the revisionist group downplayed the role of psychological mediation, stressing instead the direct relationship between cognitive processes and practical activity (Kozulin, 1986). As Davydov and Radzikhovskii (1985) explain, "In Vygotsky's last works, the problem of meaning acquired an independent character, while the idea of activity as an explanatory principle and the idea of determination through activity (even if indirectly) was not represented as logically necessary" (p. 58).

According to Kozulin (1990), Vygotsky's theory has been misconstrued in other ways as well. His views about the zone of proximal development represent a case in point. This concept has been stretched beyond recognition by Western psychologists. Kozulin claims that Vygotsky used this concept specifically to account for the complex interaction between "scientific"

concepts,[3] developed in collaboration with adults and peers, and "spontaneous" or everyday concepts, derived by reflecting on one's own activity and experience:

> For Vygotsky, zo-ped (i.e., the zone of proximal development) was specifically related to the process of the interaction between "scientific" and everyday concepts, while in later interpretations it became a catchword to indicate a dialogical, intersubjective element in the child's learning. (p. 170)

Vygotsky (1987) was critical of Piaget, who thought that spontaneous and everyday concepts were on a collision course. Vygotsky felt that Piaget did not appreciate the synergism that results from the uniting of these two ways of knowing. Thus, he concluded, the scientific concept "grows downward into the domain of the concrete, into the domain of personal experience." The spontaneous concept follows a reverse course. Initially, this type of understanding is very context-dependent; over time, however, "it moves toward the higher characteristics of concepts, toward conscious awareness and volition" (p. 220).

In Vygotskyian theory, it is important to understand the reciprocal nature of the interaction between scientific and spontaneous concepts. On the one hand, the scientific concept depends on the everyday concept: It can, according to Vygotsky (1987), "arise in the child's head only on the foundation provided by the lower and more elementary forms of generalization which

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[3]Vygotsky's use of the term scientific concept is consistent with my notion of big ideas. Both represent powerful constructs developed by the disciplines that serve both an internal and external purpose. Externally, they educate attention, allowing individuals to access the rich information present in the environment; internally, they function as richly connected hooks or anchors that help hold the cognitive structure together (Prawat, 1989). Vygotsky's examples of "scientific concepts" (i.e., Archimedes' law, the notion of exploitation in Marxist theory) are similar in level of abstractness to those cited in my earlier paper (i.e, energy flow, cycles, and change in science; part-whole relations in mathematics) (cf., Prawat, 1991).

previously exist" (p. 177). On the other hand, the scientific concept enjoys certain advantages due to its disciplinary origins. Thus, although Vygotsky talked about the fluid boundary separating scientific and everyday ways of knowing, he assigned an important role to each. Vygotsky differed from Piaget in this regard.

According to Piaget, spontaneous concepts represent privileged ways of knowing. If anything, Vygotsky (1987) turned this argument on its head: "Instruction in scientific concepts plays a decisive role in the child's mental development," he wrote (p. 220). "Scientific concepts restructure and raise spontaneous concepts to a higher level, forming their zone of proximal development" (p. 220). The precocity of this way of knowing can be attributed to two factors: First, it is the outgrowth of a collaborative effort between adult and child; second, it represents a different, more self-conscious type of understanding. Vygotsky explains,

> The earlier maturation of scientific concepts is explained by the unique form of cooperation between the child and the adult that is the central element of the educational process; it is explained by the fact that in this process knowledge is transferred to the child in a definite system. (p. 169)

This last point is very important. Individuals typically are aware of how a particular scientific concept connects with other scientific concepts in an overall system or scheme. This sense of the order of things constitutes a formidable advantage for the scientific concept. In the case of spontaneous concepts, the focus is on the object being represented, not on the concept itself. As Luria (1987) explains, "The everyday, practical concept reflects reality, but the system of concealed connections that lies behind that reality may not enter conscious awareness. Scientific concepts, as cells within a definite system, are not only formed as a consequence of verbal definition,

but always remain in conscious awareness as part of the system of connections and relationships in which they are included" (p. 366).

Vygotsky's views map nicely onto Cobb's recent discussion of a similar set of issues. Cobb (1989) based his analysis of concept formation on Meade's (1934) theory. According to this approach, there is a dialectical relationship between individual knowledge, arrived at by reflecting on one's own activity, and knowledge which is socially mediated or jointly agreed on. The latter, which falls under the scientific concept rubric, is termed institutionalized knowledge. This type of knowledge is created through a social process--"the dialectical interplay of many minds, not just one mind" (Cobb, 1989, p. 36). According to Cobb, institutionalized and individual knowledge interact in a way that mirrors the interaction between scientific and spontaneous concepts: "The children we observed engaged in consensually constrained mathematical activity,"[4] Cobb writes. Acceptance of these constraints reflects the fact that certain understandings have been negotiated and institutionalized in the classroom community. In a sense, the students and the teacher have created the institutionalized knowledge that limits or constrains each person's individual understanding. The community benefits from this process--but so too does the individual:

> It is not just that children make their individual constructions and then check to see if they fit with those of others. Children also learn mathematics as they attempt to fit their mathematical actions to the actions of others and thus contribute to the construction of consensual domains--as they participate in the process of negotiating and institutionalizing mathematical meanings. (p. 34)

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[4]Cobb cites as an example the practice of operating with units of ten and of one. This became taken for granted in the classroom he intensively studied "in that a point was reached after which a child who engaged in this practice was rarely asked to justify his or her mathematical activity" (p. 34).

Later in the same paper, Cobb (1989) discusses the importance of teachers negotiating instructional representations with students (e.g., the use of a particular manipulative in mathematics). "In effect," he writes, "the teacher has to initiate the students into the interpretive stance he or she takes with regard to the materials" (p. 39). This image of the expert initiating the novice into a particular interpretive stance bears resemblance to what goes on within various disciplinary communities. McEwan and Bull (1991) have been quite eloquent on this point recently. They compare the scientist with the pedagogue: "The scholar is no scholar," they write, "who does not engage an audience for the purposes of edifying its members." Success in any form of scholarship, they conclude, "is an inherently pedagogic affair" (p. 332). They go on to say that

> ideas are themselves intrinsically pedagogic. To understand a new idea is not merely to add to the existing stock; it is also to grasp hold of its heuristic power--its power to teach. Explanations are not only <u>of</u> something; they are also always for someone. (p. 332)

Rorty (1982) agrees with the notion that ideas are intrinsically pedagogic. Disciplines <u>do</u> continually turn up better ways of construing reality--better not because they correspond more close to reality but because they enlarge our field of vision, equipping us with tools for doing things "which could not even have been envisaged before these tools were avail . (Rorty, 1989, p. 17). It is hard to account for these intellectual breakthroughs. For all we know or care, writes Rorty, they may result from "cosmic rays scrambling the fine structure of some crucial neutrons in their (i.e., Aristole, Newton's) respective brains. . . . It hardly matters how the trick was done. The results were marvelous. There had never been such things before" (p. 17).

The role of ideas in enlarging the students' field of vision is discussed in the next section of this paper. I will conclude this section by simply reiterating the fact that scholars disagree about the extent to which Vygotsky's theory supports a strategy-based as opposed to an idea-based form of teacher-student interaction in the classroom. This is an important issue because the strategy-based interpretation of Vygotskyian theory has often been used to support an apprenticeship-like, instrumental problem-solving approach to teaching and learning. In this discussion, I have attempted to show why the current interpretation of Vygotskyian theory is problematic and to point the way toward a promising alternative interpretation--one that focuses on the important role of ideas and derives from a perceptual as opposed to information processing model of thought or cognition.

Idea-Based Social Constructivism

Several arguments in favor of an idea-based approach to social constructivism have been presented in earlier sections of this paper and elsewhere (Prawat, 1991, in press-a, in press-b): Ideas serve as lenses, directing our attention to aspects of the environment that otherwise would go unnoticed. As Gough (1989) puts it, they "educate attention." Even relatively mundane ideas can open new windows to the world. Von Foerster (1984) illustrates this with an example taken from one of Moliere's plays. Jourdain is depicted as a common man suddenly grown rich and eager to acquire the culture and sophistication of his aristocratic friends:

> On one occasion his new friends speak about poetry and prose, and Jourdain discovers to his amazement and great delight that whatever he speaks, he speaks prose. He is overwhelmed by this discovery: "I am speaking Prose! I have always spoken Prose! I have spoken Prose throughout my whole life!" (p. 40)

This one idea--the link between the spoken and written word--fills Jourdain with a sense of wonder and awe. Powerful ideas have that potential. They

create ways of thinking about phenomena that are "lithe and beautiful and immensely generative" (Bruner, 1969, p. 121).

Ideas as Perceptual Schemata

Fifteen years ago, Neisser (1976) criticized the computer-based, information processing approach to cognition; like the introspective psychology of old, he wrote, it is too narrow, rational, and laboratory-based. Furthermore, it overlooks the essential role of perception in learning and cognition. Those operating in the information processing tradition view perception as a relatively passive process, something forced on us. Although perception is not well understood by most psychologists, Neisser wrote, it may represent the best site for thinking about issues of learning and cognition. Unlike information processing, perception is more than an operation in the head; it is only comprehensible as an adaptive behavior: Perception, like evolution, is "a matter of discovering what the environment is really like and adapting to it" (p. 9).

In order to understand the perceptual process as Neisser describes it, one must understand the complex role of schemata in his theory In one sense, Neisser (1976) writes, schemata function as formats: "Formats specify that information must be of a certain sort if it is to be interpreted coherently" (p. 55). This definition of schemata is compatible with that used by information processors when they talk about frames. Because it highlights the assimilitory role of schemata, it tells only half the story. Schemata also function like plans; they anticipate the information afforded by the environment, and guide the search for that information. Neither analogy, however, adequately captures the dynamic nature of the relationship between process (i.e., schemata) and content (i.e., the information available in the environment). As Neisser explains, "The information that fills in the format at one

moment in the cyclic process becomes part of the format in the next, determining how further information is accepted" (p. 56). In talking about the planful nature of perception, Neisser stresses the importance of anticipation:

> At each moment, the perceiver is constructing anticipations of certain kinds of information, that enable him to accept it as it becomes available. Often he must actively explore the optic array to make it available, by moving his eyes or his head or his body. These explorations are directed by the anticipatory schemata, which are plans for perceptual action as well as readinesses for particular kinds of optical structure. (p. 20-21)

According to Neisser, the process of fitting in and searching out information determines perception in the same sense that genes determine the observable properties of organisms. Schemata "offer the possibility for development along certain lines, but the precise nature of that development is determined only by interaction with the environment" (p. 56).

The perceptual model advanced by Neisser (1976) thus enjoys an important advantage over existing internal-processing models of cognition: It is better suited to deal with the most vexing problem facing learning theorists: How to account for the fact that less complex intellectual structures give rise to more complex structures (Fodor, 1980; Bereiter, 1985). A transformative as well as informative relationship with the world is built into the perceptual cycle as described by Neisser: Neisser uses his perception of a stationary object as an example--the lamp on his desk. While he knows the location, size, and shape of this lamp--and that it is, in fact, a lamp--he didn't notice the vent holes around the top until he looked more closely at the object: Thus, a general schema for the lamp directed his initial search for information and allowed him to accept the new input turned up by the search; the revised schemata then created new anticipations that resulted in the pick up of yet additional information.

Neisser (1976) writes that "perception is where cognition and reality me :" (p. 9). The perceptual process plays a role in mental images, maps, and ideas. According to Neisser, these constructs are derived from the perceptual process: "In particular," he writes, they represent "the anticipatory phases of that activity, schemata that the perceiver has detached from the perceptual cycle for other purposes" (p. 130). "Such detachment is the basis for all the higher mental processes" (p. 23). Thus, in conjuring up an image, map, or idea, one need only prepare a plan for picking up the information that might be provided by the environment. As a result of this deliberate effort, the individual creates a simultaneous and somewhat contradictory anticipation--that of perceiving and not really perceiving the object or event in question. The ability to manipulate our own anticipations in this way is an important feature of our cognitive system.

Thus, ideas represent anticipations. It is to be hoped, however, these anticipations will not be detached from actual situations in the classroom. This, at least, is the position of Brown et al. (1989) and others who are arguing forcefully for contextualizing or situating the teaching of ideas. They recommend that we abandon the notion that ideas or concepts can stand alone as abstract, self-contained entities. An idea, according to Brown et al. (1989) "will continually evolve with each new occasion of use, because new situations, negotiations, and activities inevitably recast it in a new, more densely textured form" (p. 33). Ideas, when they are deployed in a particular situation, acquire a meaning that they cannot possess when they are known only in an abstract or definitional way. The key, then, is to get students to refine their ideational anticipations as they are used to describe and explain real world objects and events. This is consistent with Vygotsky's notions about how scientific and spontaneous (i.e., experiential) concepts interact.

It also fits with Bruner's (1986) ideas about the role of mental models or theories[5] in perception and cognition.

Like Neisser's schemata, Bruner's construct serves to both guide and constrain perception. Bruner is more explicit than Neisser about its ideational role, however. Some models--which resemble Vygotsky's spontaneous concepts--are based on personal experience. He cites as an example his model of how traffic moves in a big city. This model is different from the one he uses when he has to navigate around obstacles during sailing. Both, however, are susceptible to incorporation by a third, more abstract or formal model: Here, the example Bruner uses is that of the concept of flow. This model knits together a whole genre of more specific instances of a general principle: As Bruner (1986) explains, "Traffic flow and the movements of a flow in a tidal channel come to be seen in terms of where 'things'--whether sand or motor vehicles--pile up, where they move easily" (p. 48). The advantage in having a more formal or scientific concept is that it enables the individual "to keep an enormous amount in mind while paying attention to a minimum of detail" (p. 48). To use Neisser's terminology, powerful ideas create anticipations that allow one to fill in relevant detail as part of the perceptual process. This detail, in turn, enriches one's understanding of the powerful ideas.

Neisser and Bruner both emphasize that their constructs are created by individuals in the course of their interaction with the world. Furthermore, they both insist that these constructs are social phenomena, acquired through

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[5]Bruner's use of the term model or theory in this regard is interesting; the word theory is derived from the Greek theamai, or "I behold," suggesting that theories are intended to function as a kind of visual stimulus (Coles, 1989).

participation in a culture. Finally, both highlight the dual nature of the role their constructs play during cognition: Like the frames favored by information processors, schemata or mental models help structure our experience. However, this, assimilatory part of the perceptual cycle is tentative. As Neisser (1976, p. 43) puts it, "Although a perceiver always has at least some (more or less specific) anticipations before he begins to pick up information about a given object, they can be corrected as well as sharpened in the course of looking." This last quote best captures the strength of the perceptual approach to ideation: It allows ample opportunity for the exercise of imagination.

The youngster who appreciates photosynthesis--the unique role that plants play among all living things by virtue of their food-producing capability--brings a set of imaginative perceptual anticipations to bear in encountering the physical world that sets him or her apart from other, less-informed peers (Marton, 1989). The same argument can be made in other domains as well--whether the issue relates to how best to represent negative numbers at the elementary school level (Ball, 1990) or how various analytic tools like the concept of story, point of view, or subtext can be used to interpret works of literature at any level (Scholes, 1985).[6] Ideas can truly educate attention, opening the children to aspects of their world that ought to inspire a sense of wonder and awe. This should be a high priority goal in education. It has

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[6]Scholes's (1985) book, Textual Power: Literary Theory and the Teaching of English, is well worth reading for those interested in an idea-based approach to reading and literature. The English teacher's job, according to Scholes, is to provide students with the analytic tools that allow them to penetrate the surface of texts. Scholes calls these tools codes. Genre and style are two examples. These concepts are useful, according to Scholes, "because they give access to the invisible forces that shape textual production, just as the concept of 'language' gives us access to the forces that shape our speech" (Scholes, 1985, p. 3).

been my contention throughout this paper that such a goal is unlikely to be achieved as long as teachers remain preoccupied with instrumental problem solving--with the role of problems instead of possibilities--in their efforts to teach for higher levels of understanding.

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